Bromegrass in Alaska. III. Effects of Planting Dates, and Time of Seeding-Year Harvest, on Seeding-Year Forage Yields and Quality, Winter Survival, and Second-Year Spring Forage Yield

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Summary

Objectives of this study were to (a) determine yields and quality of forage that could be obtained in the seeding year from smooth bromegrass (*Bromus inermis*) seeded in spring without a cereal companion crop, and (b) determine whether planting dates and date of the seeding-year harvest influenced subsequent winter survival and forage yield in the following year.

Bromegrass plots were harvested for forage yield once during the seeding year on several dates approximately 10 days apart during August, September, and early October; effects of those harvest dates were measured by comparing yields of all plots harvested on the same date in the second year of growth. Five of the six experiments were conducted at the University of Alaska's Matanuska Research Farm (61.6°N) near Palmer in southcentral Alaska, and the other was at the Research Center in Palmer.

- Yields of 'Manchar' bromegrass forage increased regularly from near 0.6 T/A in early August to about 1.6 T/A in early September; thereafter, yields changed little with later harvests.
- Percent dry matter in herbage increased from about 17% in early August to 26% to 28% by early October.
- Percent crude protein in herbage decreased regularly from about 23% in early August to 12.5% in early October.
- Stored food reserves just prior to onset of winter conditions (mid-October) were highest in plants that had been harvested in early August; levels were lower with progressively later harvests until about 10 September, and then were slightly higher in plants that had been harvested later.
- Where seeding-year harvest had been taken about 10 September, winter survival of Manchar bromegrass was poorest, thinned stands were weediest in the second year, and second-year forage yield was lowest (mean = 0.6 T/A).
- With seeding-year harvest dates progressively earlier or later than 10 September, winter survival and forage yields of Manchar the following year improved markedly.
- Earliest seeding-year harvest of Manchar (on 10 August) resulted in the highest second-year, first-cut forage yield of about 2.25 T/A. The latest seeding-year harvest about 1 October resulted in a modest second-year, first-cut forage yield of about 1.2 T/A.
- Considering the two least-injurious times for seeding-year harvest of Manchar, the earliest harvest on 10 August resulted in a low seeding-year yield of high-quality forage (as indicated by high percent crude protein and low percent dry matter), while the latest harvest (1 October) resulted in a considerably higher yield but of lower quality (low percent crude protein, high percent dry matter).
- 'Polar' bromegrass planted in mid-May produced uniformly high forage yields (between 1.6 and 1.9 T/A) on six different seeding-year harvest dates from 19 August to 10 October.
- Polar bromegrass planted 1 June produced progressively increased seeding-year yields from about 1 T/A on 19 August to near 2 T/A on 10 October.
- Polar bromegrass planted in mid-June produced much lower seeding-year yields, increasing from a low of about 0.25 T/A on 19 August to about 1 T/A on 1 October.
- Polar bromegrass stands were most winter-injured following seeding-year harvest on 31 August; stands were markedly less injured following seeding-year harvest only 12 days earlier on 19 August, and were increasingly less injured as seeding-year harvest dates were progressively later than the end of August.
- These findings revealed that spring-seeded bromegrass is very sensitive to time-of-harvest in the seeding year. Stands were weakened and predisposed to severe winter injury when harvested at an inappropriate time.
- Conversely, bromegrass stands were favored toward better winter survival by avoiding seeding-year harvest between about 20 August and 20 September.
- For best seeding-year forage yields of high quality, harvested when the stand will not be predisposed to winter injury, a winterhardy bromegrass should be planted no later than mid-May and seeding-year harvest should be no later than about 20 August.
- These findings provide growers with information that should be helpful in choosing among management options in bromegrass establishment. Informed choices can achieve grower goals while avoiding ill-timed operations that could weaken the grass and predispose it to winter injury.
- These results were obtained in experiments with very effective herbicidal control of broadleaf weeds. Similar results in farm practice will require equally effective control of weeds.

Introduction

Smooth bromegrass (*Bromus inermis* Leyss.), native to Eurasia, is an important, long-lived perennial forage species. Its usefulness in Alaska was recognized early (Aamodt and Savage 1949; Alberts 1933; Irwin 1945) and it has become the dominant perennial forage on rotational croplands in Alaska; it is used as well for non-cropland, soil-stabilization purposes.

There are two types of smooth bromegrass, northern and southern, and only the most winterhardy strains of the northern type are dependably hardy for use in Alaska (Anonymous 1953?; Klebesadel 1970; 1993a; Klebesadel and Helm 1992). The cultivar Polar, developed in Alaska, incorporates germplasm of northern-adapted, native North-American pumpelly bromegrass, (*B. pumpellianus* Scribn.) and is the most winterhardy cultivar available for use in Alaska (Klebesadel and Helm 1992; Wilton *et al*. 1966).

Establishing Stands

Once established, stands of winterhardy smooth bromegrass can remain productive for many years with adequate fertilization. To realize the full productive potential of bromegrass, however, requires at the outset the successful establishment of a full, vigorous stand. A previously reported study with row seedings at this location determined that early planting of northern-adapted bromegrass was necessary for optimum seed production (Klebesadel 1970). However, establishment of broadcast-seeded bromegrass stands for forage production has been little studied in Alaska.

Perennial forage grasses and legumes, including bromegrass, often are established in association with a small-grain companion crop (Buxton and Wedin 1970; Decker and Taylor 1985; Klebesadel and Smith 1959, 1960; Sprague *et al*. 1963). The annual companion crop, harvested at an immature stage for forage, or at maturity for grain and straw, provides a crop during the year that the perennial forage crop becomes established and also tends to suppress weed growth. However, competition of the faster-growing, taller companion crop for light and soil moisture also suppresses the vigor of the establishing forage seedlings (Buxton and Wedin 1970; Klebesadel and Smith 1959; Lueck *et al*. 1949; Waddington and Bittman 1983). This results in relatively low forage yields the following year, especially in the first cutting.

Moreover, if lodging of a cereal companion crop occurs, the result can be more drastic weakening of the forage seedlings, uneven stands, or complete loss of the smothered forage seeding. Lodging of cereal crops is common in Alaska due to normally increasing rainfall during the latter half of the growing season. The threat of lodging can be minimized, and competitive effects lessened, by harvesting the companion crop one or more times for forage (Klebesadel and Smith 1960).

Generally, however, establishing perennial forage species with a cereal companion crop is more appropriate at more southern latitudes where growing seasons are longer than in Alaska. There, after harvest of the cereal companion crop, the forage seedlings have a longer period of growth, free of competitive effects, to develop into vigorous plants before termination of the growing season.

An alternative to establishing perennial forages in association with a cereal companion crop is to seed them alone and employ a selective herbicide to control weeds (Kust 1968; Schmid and Behrens 1972). Spring seeding of bromegrass without a cereal companion crop and with good weed control permits seedlings to grow unimpeded, eliminates the hazard of smothered seedlings from a lodged companion crop, can provide a forage crop for harvest in the seeding year, and results in larger, more vigorous plants to contend with stresses imposed during winter. However, most reports on this procedure have dealt with legumes (Kust 1968; Schmid and Behrens 1972).

Little is known of forage yields that may be obtained from spring-seeded bromegrass in the year of planting in high-latitude areas. In addition, information is lacking concerning the most desirable time to plant and to harvest bromegrass in the seeding year. Aamodt and Savage (1949), referring to establishing perennial forages in Alaska, stated: "Where the snow blows off, leaving the soil exposed, it is best not to clip or pasture . . . at all the first season." No basis was supplied for this contention; however, since their report was based on a brief visit to Alaska, it may have derived from experience of local farmers.

Grass planting and seeding-year harvest should be done when both will result in maximum yield of best quality forage. However, of greater importance in establishing a long-term grass stand, is the concern that a seeding-year harvest should be taken when it will be least harmful to grass establishment, stand vigor, and subsequent winter survival.

Stored Food Reserves and Winter Survival

For best winter survival in areas of cold winters, plants require high levels of stored food reserves. Stored reserves are needed (a) as energy for development of freeze tolerance, (b) for maintenance of plants during the winter dormant period, and (c) as the energy source for initiation of new growth the following spring (Smith and Nelson 1985).

Levels of stored food reserves in plants can be governed both by genetic and by management influences. As an example of genetic influence, studies at this location have found that plants of northern-adapted ecotypes stored higher pre-winter levels of food reserves during the seeding year, and survived winters better, than ecotypes within the same species adapted at more southern latitudes (Klebesadel 1985, 1991, 1993a, 1993c; Klebesadel and Helm 1986). Reynolds and Smith (1962) and Smith and Nelson (1985) reported how differential management, for example different cutting schedules, also influence storage and utilization of plant food reserves.

Levels of food reserves in storage tissues of plants are commonly determined through laboratory procedures and reported as "total available carbohydrates" (Reynolds and Smith 1962) or "total nonstructural carbohydrates" (Smith 1981). Another technique is to remove plants from the field to a warm, dark chamber and weigh the mass of etiolated growth produced (in the absence of photosynthesis) until total exhaustion of the stored food reserves in the plants (Burton and Jackson 1962; Graber et al. 1927). The latter technique was employed in one experiment in this study.

This Investigation

Objectives of this study were to compare effects of various times of planting, and different times of seeding-year harvest, on smooth bromegrass spring-seeded alone. Effects were measured in seeding-year forage yield and quality, autumn storage of food reserves, winter survival, and subsequent spring forage yield.

The results presented are from five separate field experiments conducted at the University of Alaska's Matanuska Research Farm (61.6°N) near Palmer in southcentral Alaska and one at the Palmer Research Center.

Experimental Procedures

Each of the six broadcast-seeded plot experiments was of two-year duration and they were conducted during two periods; Exps. I, II, III, and IV during the years 1962 to 1966, and Exps. V and VI during 1982 to 1984. All were grown in Knik silt loam except Exp. I which was in Bodenburg silt loam; all were in areas selected for good surface drainage. The following rates of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) in pounds per acre were disked into each plowed seedbed just prior to planting the six experiments: 30-30-15, 24-96-48, 28-112-56, and 28-112-56, respectively, in Exps. I, II, III, and IV, and 32-128-64 in Exps. V and VI.

Manchar smooth bromegrass, a cultivar selected in the Pacific Northwest states, was seeded in the first four experiments, and the Alaska cultivar Polar was seeded in the last two. Both cultivars were planted at 20 pounds of pure live seed per acre using a corrugated-roller seeder and no companion crops were planted. Individual plot size was 5 x 25 ft. in Exps. I and II, 5 x 20 ft. in Exps. III and IV, and 5 x 16 ft. in Exps. V and VI. Randomized complete block experimental designs were used with six replications in Exps. I, II, and III; four replications were used in Exps. IV, V, and VI. Exps. V and VI utilized split-plot experimental designs with three planting dates as main plots and seeding-year harvest dates as sub-plots.

A single planting of each entire experiment was done in Exps. I, II, III, and IV; planting dates were 1 June 1962 in Exp. I and 28 May in the next three in 1963, 1964, and 1965. The three planting dates in Exp. V were 18 May, 1 June, and 15 June 1982; in Exp. VI they were 17 May, 1 June, and 16 June 1983.

Each plot was harvested once in the seeding year and harvests were at approximately 10-day intervals. Six dates of harvest from 10 August to 1 October were compared in Exps. I, II, and IV, seven dates from 1 August to 2 October in Exp. III, and six dates from 19 August to 10 October in Exps. V and VI. All forage yield determinations from broadcast-seeded plots were made by harvesting a swath 2.5 feet wide (leaving about a two-inch stubble) along the centerline of each plot after which grass on the entire plot area was clipped and removed. Small, bagged samples from each harvest were dried to constant weight at 140°F to determine percent dry matter used to calculate oven-dry yields. Samples were then ground finely and analyzed for crude protein (N x 6.25) by the Kjeldahl method. All yields are reported on the oven-dry basis.

In October, after killing frost, all plots were trimmed to a uniform two-inch stubble to prevent differential snow retention on plots during winter. An exception to this occurred in Exp. V as described in the Results and Discussion section.

In spring of the year following establishment, each experiment was topdressed uniformly with commercial fertilizer to supply N, P_2O_5, and K_2O at 126, 96, and 48 lb/A, respectively. Later the same year, all plots in each experiment were harvested in late June or early July for forage yield to provide a uniform quantitative evaluation of the effects of time-of-harvest in the seeding year. Second-year evaluation harvest dates were: Exp. I—3 July 1963; Exp. II—2 July 1964; Exp. III was not harvested (see Results and Discussion); Exp. IV—28 June 1966; Exp. V—22 June 1983; and Exp. VI—20 June 1984. Harvest procedures were the same as those employed during the year of seeding.

On 28 May in the year of establishment of Experiment III, Manchar bromegrass was seeded also in rows 3 feet apart (referred to hereinafter as Exp. IIIa) in an area adjacent to the broadcast-seeded plots. A very light rate of seeding was used; when seedlings were 2 to 3 inches tall, they were thinned by hand to leave individual plants spaced approximately 20 inches apart in the rows. Some selectivity was employed to leave plants approximately equal in size and vigor.

On each of the seven dates that broadcast-seeded plots were harvested in the adjacent Exp. III, randomly selected five-plant lots in the rows of individual plants in Exp. IIIa were hand-clipped to remove all aerial growth above a two-inch stubble. One five-plant lot was clipped in each of four replications. Clipped growth of each group of five plants was bulked, dried to constant weight at 140°F and weighed.

On 16 October of the same year, all individual plants that had been clipped on the various harvest dates were reclipped and aerial growth above a two-inch stubble was bagged, dried, and weighed for each plant. Immediately after clipping, each plant was dug carefully to retain most roots and all rhizomes and was potted in saturated soil in a 1-gallon metal can with a perforated bottom. All cans were then placed into indoor dark storage with the basal 1/2 inch of each can immersed in water. Temperature in the dark storage was maintained at 66 $\pm$ 2°F. A fungicide (PCNB) in water spray was applied approximately twice weekly to prevent development of molds on the grass during growth in darkness. To measure stored food reserves in the plants, etiolated growth produced in the dark was clipped at the point where it emerged from the 2-inch stubble at approximately 10-day intervals until food reserves were exhausted and no more growth appeared. Growth clipped on each date was bagged, dried to constant weight at 140°F and weighed to provide a comparative measure of stored food reserve levels present in plants as of 16 October (near onset of winter conditions).

Results and Discussion

Note on one incomplete experiment in this series: Experiment III differed from all others in this study in that a relatively constant and considerable layer of snow remained in place on that field site for most of the winter. When the snow melted in spring, gray masses of mycelium of a snowmold pathogen were in evidence over much of the experimental area. Later, when the grass initiated growth, it was evident that many areas had sustained considerable injury from the snowmold in uneven patterns across the experiment to such an extent that forage yield data would be unrelated to experimental treatment effects. Therefore, that experiment was terminated and no second-year yields were harvested.

Rather than totally omitting the incompleted Exp. III from this report, the fate of that experiment is related to inform growers that snowmold injury occasionally can be a factor in this area. It is most likely to occur when snow cover remains in place over winter (Kallio 1966). The common occurrence of removal of snow by strong winter winds in this area exposes overwintering forages to the potentially damaging stresses of low or widely oscillating air temperatures and dehydration; however, that snow removal does protect plants against injury from snowmold organisms that can thrive under an insulating snow covering.

Inasmuch as (a) the seeding-year harvest data from Exp. III were generally similar to the three other similar experiments (Exps. I, II, IV), and (b) second-year forage yields from Exp. III were not harvested, no data from Exp. III were used in the graphs of seeding-year or second-year forage yields; therefore only results from the same three experiments (I, II, and IV) appear in both graphs. (Results from the adjacent Exp. IIIa, however, involving individual seedlings clipped at various times and that were moved indoors in mid-October, are included in this report).

Forage Yields During the Seeding Year

Exps. I, II, IV; Manchar bromegrass with one planting date: When planted near 1 June, Manchar forage yields increased with each progressively later harvest date from 10 August until 10 September (Fig. 1). Yields more than doubled during the one-month growing period from 10 August (mean yield = 0.66 T/A) to 10 September (mean yield = 1.58 T/A). However, yields from the two harvests later than 10 September changed little from those obtained on 10 September.

Exps. V, VI; Polar bromegrass with three planting dates: The three different planting dates in Exps. V and VI influenced considerably the seeding-year yields of Polar bromegrass (Fig. 2). With planting near mid-May, only minor differences were noted among yields from the different harvest dates; yields ranged from 1.65 to 1.91 T/A. Yields from grass planted 1 June generally increased from first to last dates of harvest, ranging from 1.07 T/A with the earliest harvest (19 August) to 1.98 T/A at the 10 October harvest in Exp. VI.

The latest planting date (16 June) in Experiment VI was lost to a very vigorous and dense volunteer growth of annual bluegrass (*Poa annua* L.) in much of that experimental area. After initial attempts to remove the bluegrass by hand weeding, it became apparent that the

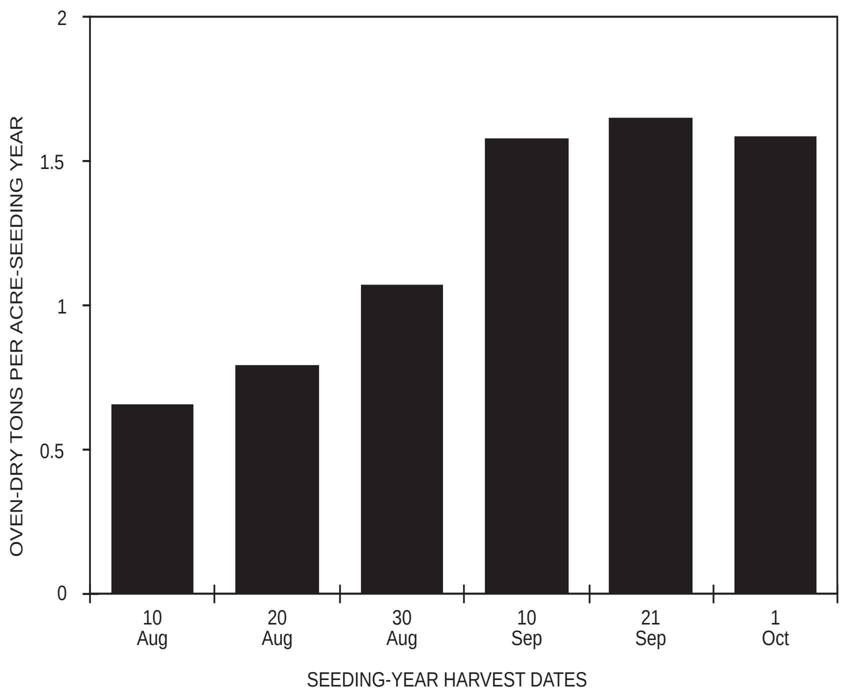

Figure 1. Three-experiment means of Manchar bromegrass forage yields obtained on different dates of seeding-year harvest. Harvest dates are means for Exps. I, II, and IV that were planted 1 June, 28 May, and 28 May, respectively.

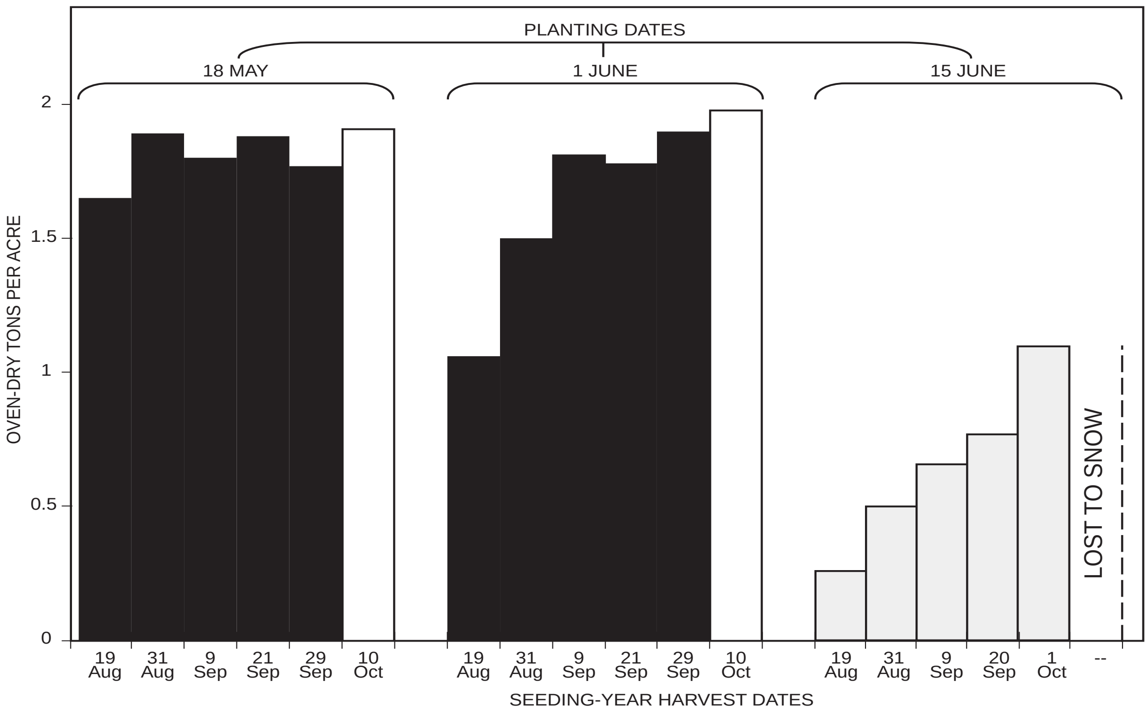

Figure 2. Seeding-year forage yields of Polar bromegrass as influenced by three different planting dates and several different dates of harvest of grass planted on each date. Solid bars represent mean yields and mean harvest dates from Exps. V and VI. Stippled bars represent yields and harvest dates from Exp. V only (mid-June planting in Exp. VI was lost due to vigorous weed growth); open bars represent data from Exp. VI only (planned 10 Oct. harvest in Exp. V was buried under snow).

disruption to the bromegrass seedlings would not leave adequate and representative stands for meaningful experimental results; therefore the entire 16 June planting in Exp. VI was destroyed to prevent seed production by the annual bluegrass. As a result, Figure 2 presents results for the first two plantings for both Exp. V and VI, but only for Exp. V for the mid-June planting.

Seeding-year yields from the latest (15 June) planting date (Exp. V only) were much lower than from earlier planting dates and increased regularly with progressively later harvest dates from 0.26 T/A on 19 August to 1.11 T/A at the last harvest on 1 October. The planned final seeding-year harvest on 10 October in Exp. V could not be taken because of heavy snowfall on 8 October.

Percents Dry Matter and Crude Protein in Forage

Exps. I, II, IV: Mean percent dry matter in the herbage increased as the grass advanced in development with progressively later dates of seeding-year harvest (Fig. 3). The increase was from about 17.5% when herbage was leafy and succulent in early August, to 26% to 28% by early October when herbage was much taller and with a higher proportion of stems to leaves.

Percent crude protein in the herbage, an indicator of forage nutritional quality, declined rapidly during the period from early August (about 23%) to early October (about 12.5%).

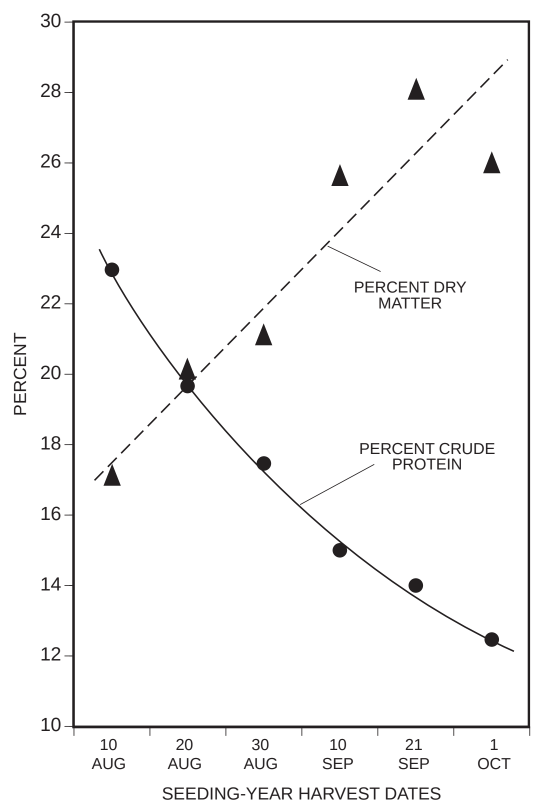

Figure 3. Three-experiment means of percent dry matter and percent crude protein in Manchar bromegrass herbage at six different dates of seeding-year harvest. Harvest dates are means for Exps. I, II, and IV that were planted 1 June, 28 May, and 28 May, respectively.

Influence of Seeding-Year Harvest Dates on Pre-Winter Levels of Stored Food Reserves

Exp. IIIa: As with the broadcast-seeded plots, the amounts of aerial growth harvested from individual plants generally increased with progressively later dates of harvest (Fig. 4-A). Oven-dry grams of herbage per plant increased from 1.5 on 1 August to about 15 on 11 September; thereafter the data indicated continued increase but the yield on 2 October was somewhat less than 10 days earlier.

When those same plants were clipped in mid-October (Fig. 5), prior to being dug, potted, and moved indoors to measure stored food reserves, amounts of regrowth produced after the seven prior harvest dates decreased as those earlier harvest dates had been progressively later (Fig. 4-B).

Oven-dry grams of regrowth herbage per plant decreased from 13.7 on plants that had been harvested 1 August to 0.3 on plants that had been harvested 2 October, only two weeks before plants were reclipped and removed from the field.

After potted plants were placed in the warm, dark chamber, etiolated growth was clipped and weighed at approximately 10-day intervals (Figs. 6, 7) until no more was produced and plants died. Four, 10-day growth periods served to effectively exhaust all stored food reserves; very minute amounts of regrowth appeared on a few plants in the fifth growth period that, when dried and weighed, did not add to data presented in Figure 7.

Stored food reserves differed considerably among

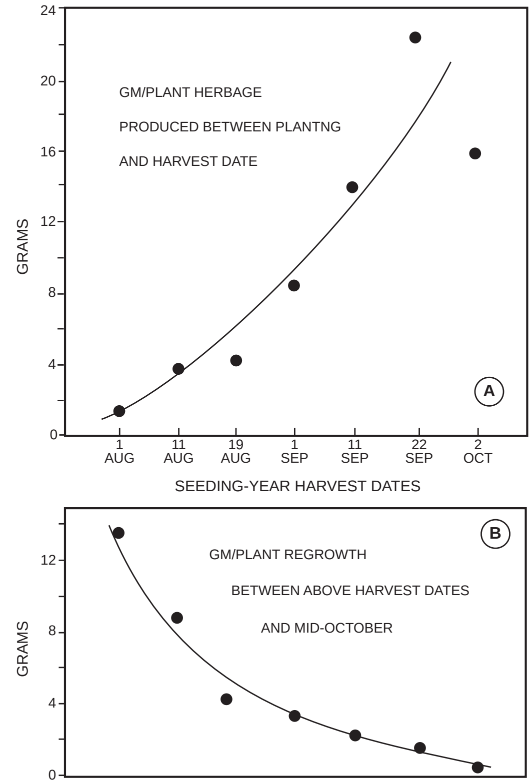

Figure 4. (Graph A) Oven-dry grams of herbage per plant harvested on various dates during the seeding year from individual Manchar bromegrass plants grown in rows seeded 28 May in Exp. IIIa. (Graph B) Oven-dry grams of herbage regrowth per plant harvested in mid-October from the same plants as in the upper graph.

Figure 5. Onslaught of blizzard shown in above photo on 16 October was interpreted as a clue that the growing season had ended and the time had arrived to remove individual bromegrass plants from the field for determination of stored food reserves in Exp. IIIa. Agronomy foreman Darel Smith is locating, clipping, and potting plants for transfer to indoor chamber.

Figure 6. Amounts of etiolated growth produced on representative individual plants of Manchar bromegrass in an indoor dark chamber as influenced by different dates of seeding-year harvest of topgrowth when plants had been growing in the field (Exp. IIIa). Plants were spring-seeded 28 May and grew as individual plants in rows; green topgrowth was harvested from each plant on a different date in the year of planting (Fig. 5-A). All plants were clipped again (Fig. 5-B) to a 2-inch stubble when dug from the field on 16 October, potted immediately into containers, then placed into the indoor dark chamber. Quantity of etiolated growth produced provides a measure of the amount of stored food reserves present in plants near onset of winter. Etiolated growth was clipped from plants, dried, weighed, and data appear in Figure 7. Harvest dates of green topgrowth in the field were: A = 1 Aug., B = 11 Aug., C = 19 Aug., D = 1 Sep., E = 11 Sep., F = 22 Sep., G = 2 Oct.

the different seeding-year harvest treatments (Figs. 6,7). Highest level of reserves was found in plants that had been harvested earliest (1 Aug), and an intermediate level was present in plants harvested 10 days later on 11 August. All of the five later dates of harvest resulted in generally low levels of stored food reserves, but with no clear pattern of differences.

Fulkerson (1970), in Ontario, used "root density" as a measure of stored food reserves in alfalfa and, at each of three locations, found that fall cutting on critical dates generally reduced (a) root density as measured in early winter, and (b) alfalfa stands, plant heights, and forage yields the following year.

Smith and Graber (1948) in Wisconsin reported that seeding-year harvest of biennial sweetclover in mid-September resulted in plants (a) entering the winter period lower in both percentage and quantity of stored food reserves (readily available carbohydrates), and (b) that produced less growth the following spring than plants harvested earlier or later or not harvested in the seeding year.

Winter Survival and Second-Year Forage Yields With One Planting Date

Exps. I, II, IV; Manchar Bromegrass: Seeding-year harvest dates had dramatic effects on Manchar bromegrass winter survival and growth in the second year. Grass stands in plots harvested 10 September were visibly thinned (Fig. 8), surviving plants were

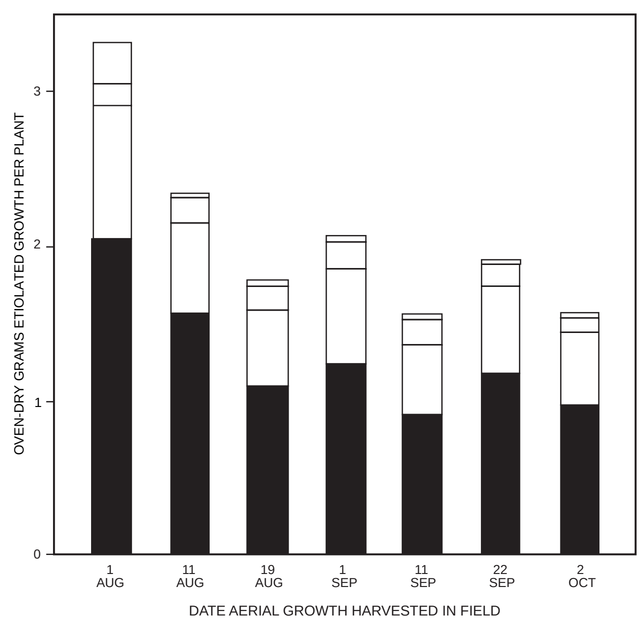

Figure 7. Stored food reserves as measured by amounts of etiolated growth produced by Manchar bromegrass plants that had been grown in the field as individual plants in rows, had topgrowth removed on the dates indicated above, were again clipped to a 2-inch stubble in mid-October, then were dug and potted into containers and placed immediately into a warm, dark chamber (Exp. IIIa). Black basal portion of each bar represents amount of etiolated growth produced between potting on 16 October and first harvest on 26 October. Horizontal lines higher on each bar represent successive harvests of etiolated growth on 5, 16, and 27 November until plants reached exhaustion.

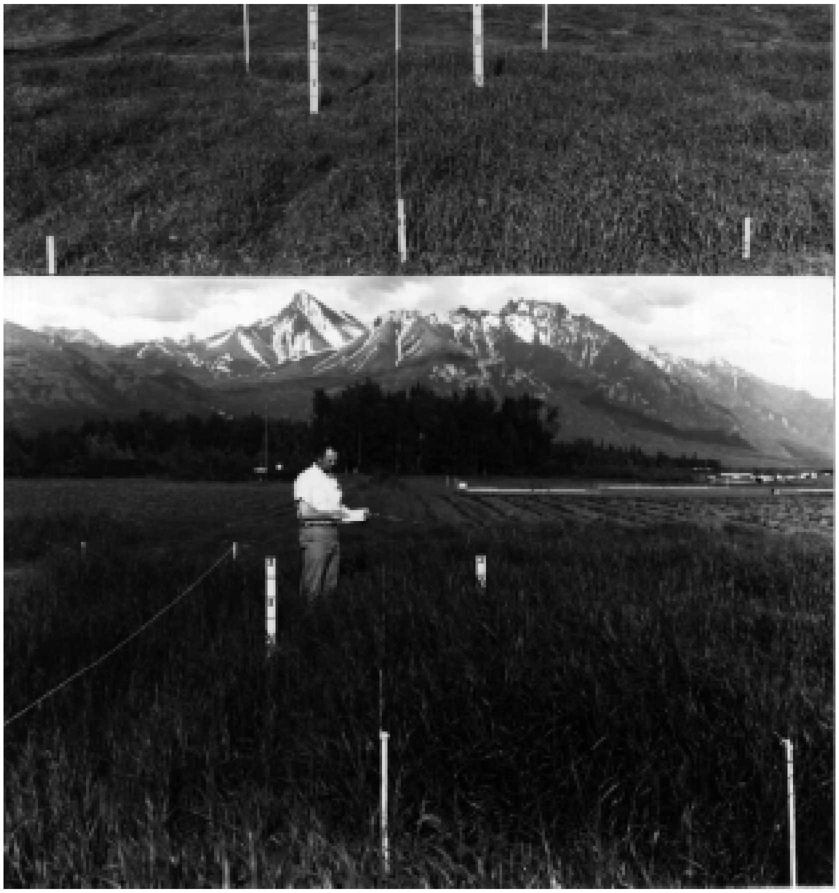

Figure 8. (Upper photo): Two plots of Manchar bromegrass photographed 26 May showing dissimilar amounts of winter injury and vigor in spring growth as influenced by different dates of seeding-year harvest the previous year. Injured stand in plot to left of center was harvested 10 September; vigorous grass to right of center was harvested 10 August. (Lower photo): The same two plots one month later (25 June) showing that the differences in plant density, height, and vigor persisted. Numbers on white stakes indicate height in feet. (Experiment I).

less vigorous, and by harvest date the thinned bromegrass stands had permitted increased invasion of weeds.

The effects of different seeding-year harvest dates were obvious in the considerable range of forage yields in the uniform evaluation harvest of all plots on the same date in the year after establishment (Fig. 9). Highest forage yields, about 2.2 T/A, were obtained from plots harvested earliest (mean date 10 Aug.) in the seeding year. Yields decreased markedly with plots that had been harvested on successively later dates in the seeding year until they reached a low of about 0.6 T/A from plots that had been harvested on 10 September, the same harvest date that had resulted in the lowest pre-winter level of stored food reserves (Fig. 7). With plots harvested successively later than 10 September in the seeding year, forage yields were progressively higher (Fig. 9), though yields from plots that had been harvested 1 October were only about one-half of the highest yields (plots that had been harvested 10 August).

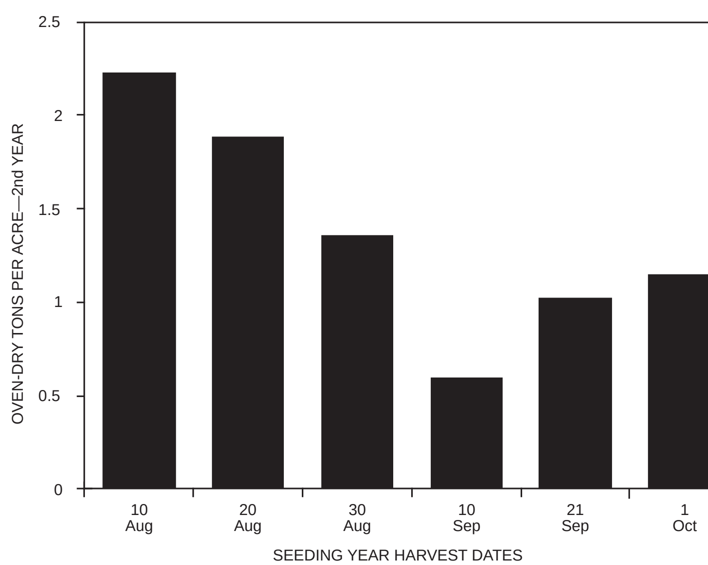

Figure 9. Three-experiment means of Manchar bromegrass forage yields in the first-cutting (mean date = 1 July) of the second year of growth. Differences in yields were caused by different dates of seeding-year harvest during the previous year; seeding-year harvest dates are means for Exps. I, II, and IV.

Second-Year Forage Yields With Three Planting Dates

Exps. V and VI; Polar Bromegrass: Exps. V and VI incorporated four major procedural differences from the earlier experiments: (a) the cultivar Polar was used instead of Manchar; (b) three planting dates were used instead of one; (c) the earliest seeding-year harvest was 19 August instead of 10 August; and (d) the final harvest date was planned for 10 October instead of 1 October. However, the 10 October harvest was not accomplished in Exp. V because of a heavy snowfall on 8 October (Fig. 2); hence, that treatment remained unharvested until thawing temperatures in late December melted the snow, permitting clipping and discarding of the dead growth on the previously unharvested plots and trimming the entire experiment to about a uniform two-inch stubble on 30 December 1982.

As in the earlier experiments with Manchar, the early spring growth in 1983 of Polar in Exp. V exhibited considerable differences in winter survival and vigor as influenced by seeding-year harvest dates during 1982 (Fig. 10); those visual differences were apparent also in the uniform evaluation harvest of all plots on 22 June 1983 (Fig. 11).

In Exp. V, effects of the seeding-

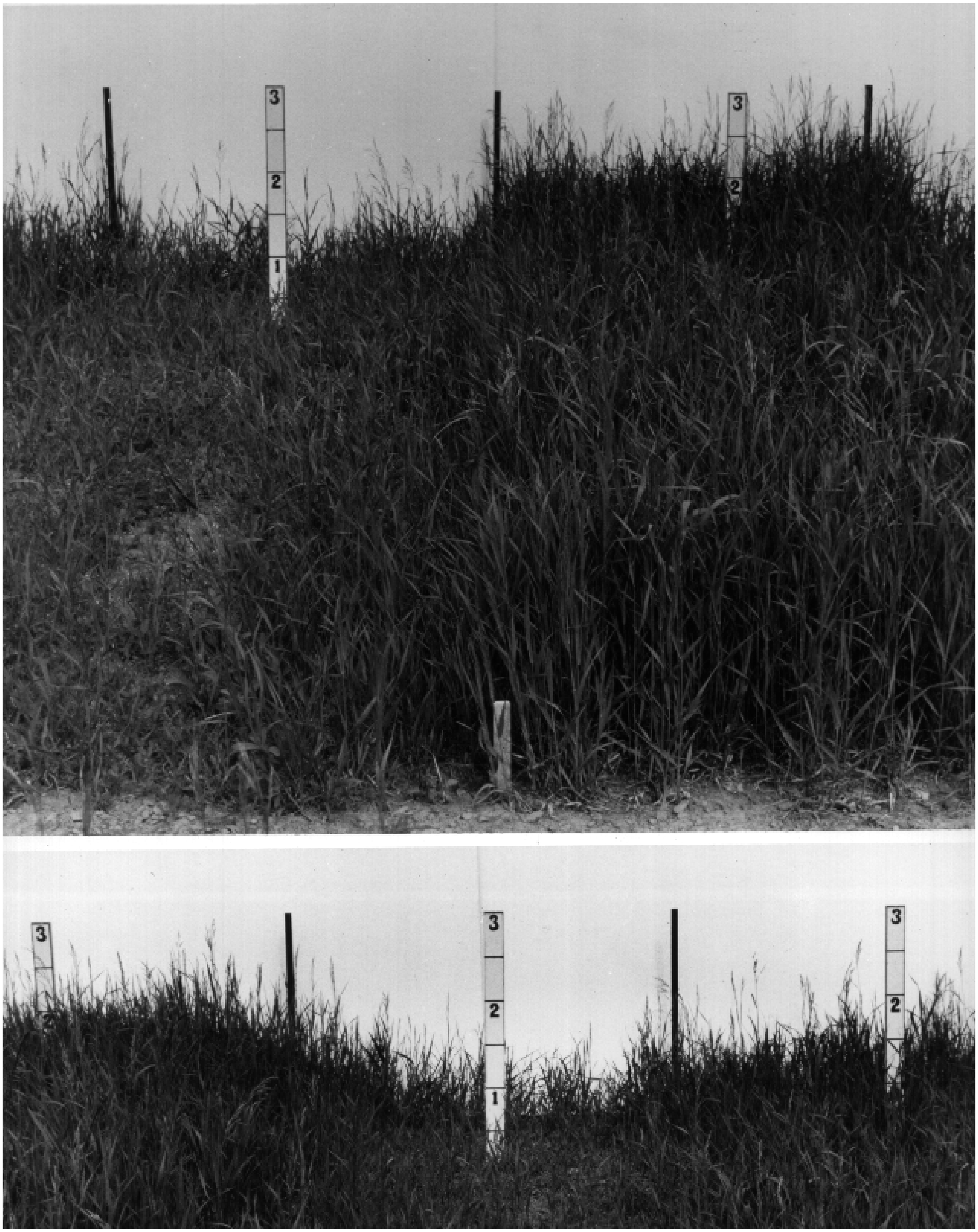

Figure 10. Winter survival and spring vigor of plots of Polar bromegrass on 13 June 1983 as influenced by different seeding-year harvest dates in 1982. (Upper photo): Winter-injured plot on left was harvested 31 August, right plot with vigorous growth was harvested 12 days earlier on 19 August. (Lower photo): Winter-injured, non-vigorous plot in center was harvested 31 August, plot on right was harvested only 9 days later on 9 September. Plot on left was scheduled for harvest on 10 October but heavy snowfall on 8 October prevented harvest until 30 December. Numbers on white stakes in center of each plot indicate height in feet. (Exp. V, these plots planted 1 June 1982).

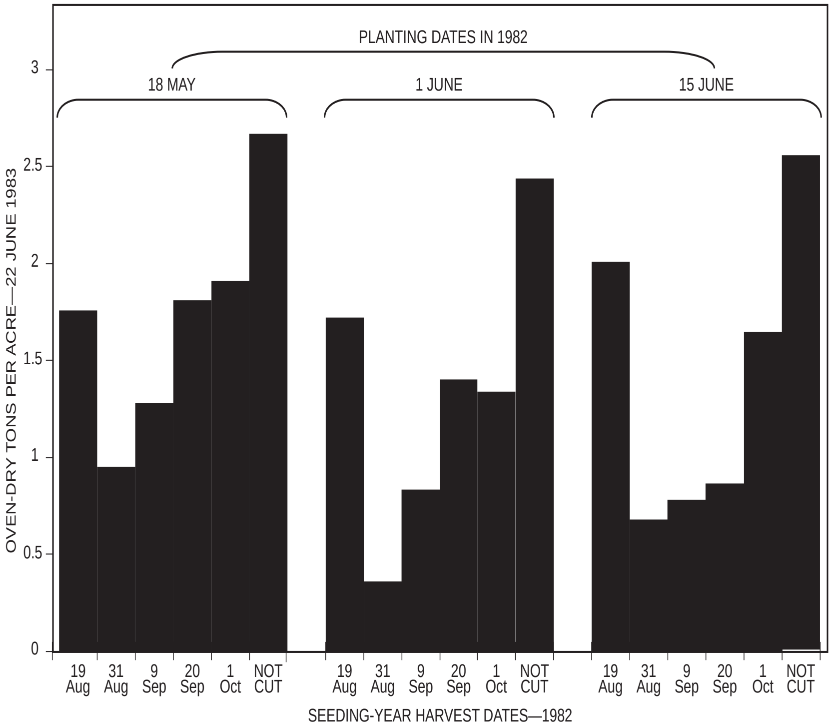

Figure 11. Forage yields of Polar bromegrass on 22 June 1983 as influenced by three planting dates (18 May, 1 June, 15 June) in 1982 and five different seeding-year harvest dates approximately 10 days apart in August, September, and October of 1982, plus one treatment involving no seeding-year harvest during the growing season—intended harvest on 10 October was precluded by heavy snowfall on 8 October (Exp. V).

year harvest dates in 1982 were generally similar for all three dates of planting, as indicated by second-year yields of all plots harvested 22 June 1983 (Fig. 11). However, the most harmful seeding-year harvest date for Polar bromegrass was 31 August instead of 10 September that was most harmful to Manchar in the earlier experiments.

A marked difference was noted between the very low yields in 1983 from plots that had been harvested 31 August 1982 and the much higher yields from plots that had been harvested only 12 days earlier on 19 August (Fig. 11); this effect was consistent within all three planting dates. Inasmuch as this date-of-harvest effect was similar with plants of three different ages when cut on 31 August (105, 91, and 77 days after planting), the harmful effect logically was due to the length of the growing period between the 31 August harvest and killing frost, which was the same for all planting dates.

With seeding-year harvests successively later than 31 August, second-year yields gradually increased, and highest yields were obtained from plots not harvested until the dead growth was clipped and removed 30 December.

In Exp. VI, the effects of seeding-year harvest dates were less evident (Fig. 12) than in Exp. V. With the plots planted 17 May, no seeding-year harvest dates depressed second-year yields. However, with plots planted 1 June, the pattern seen in Exp. V was again evident; harvest on 30 August was the most harmful, though the depressing effect was much less dramatic than in Exp. V. The considerable winter injury (to plots harvested 30 August) in grass planted 1 June versus in the 17 May planting differed from Exp. V where the injurious effects were apparent in all three plantings.

Inasmuch as Exps. V and VI were grown in the same field and therefore had similar exposure to winter stresses, the considerably greater winter injury noted in Exp. V after the winter of 1982-83 suggests that the two winters differed in stresses imposed on plants.

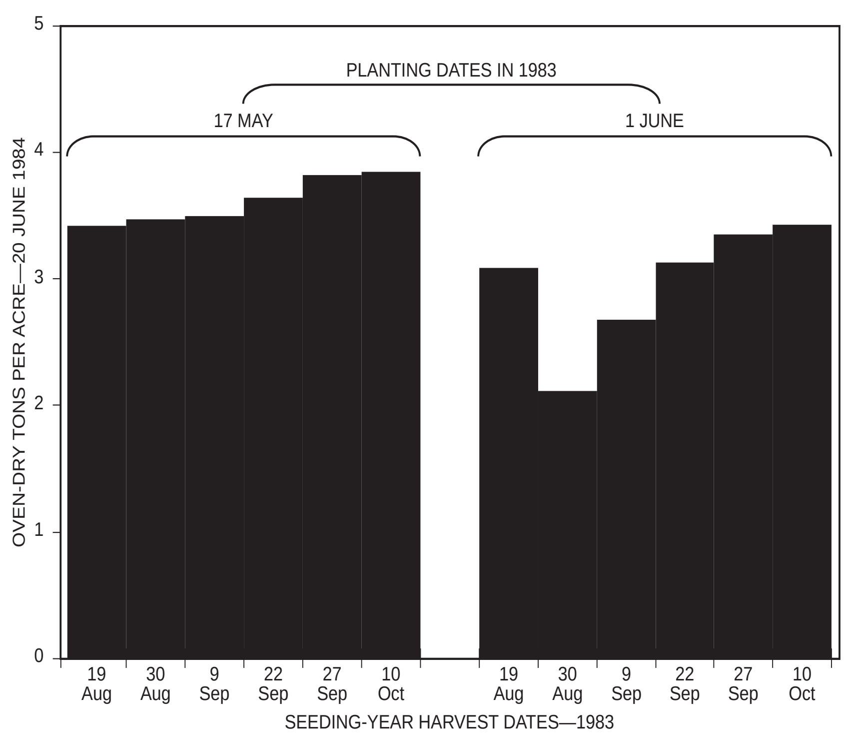

Figure 12. Forage yields of Polar bromegrass on 20 June 1984 as influenced by two planting dates (17 May, 1 June) in 1983 and six different seeding-year harvest dates approximately 10 days apart in August, September, and October of 1983 (Exp. VI).

Weather records for the Matanuska Research Farm support that viewpoint; the winter of 1982-83 had three cold periods of four to six days duration when minimum air temperatures were at or below -10°F, and one period had four consecutive days of -16° to -21°F. Interspersed with those cold periods were six thaw periods during November, December, January, and February, each of three to seven days duration, during which temperatures ranged from +39° to +47°F.

In contrast, the 1983-84 winter that resulted in less plant injury had only two cold periods when temperatures were lower than -10°F, one of two days and the other of five days duration (during the latter, however, minima were between –17° and –25°F for 4 days). Moreover, only one thaw period of temperatures over 40°F occurred for three days in mid-January.

The occurrence of warm periods during winter might be interpreted as indicating mild conditions and a lack of stress on plants. The opposite is true, however, especially if warm periods alternate with very cold temperatures as occurred during the winter of 1982-83 and other winters unusually injurious to overwintering plants locally (Klebesadel 1974).

Smith (1964) stated "Air temperatures that alternate from above to below freezing can be very damaging, especially when there is little or no insulation on the soil surface." Dexter (1941) reported that warm periods during winter cause dehardening (loss of freeze tolerance) in plants, and that rehardening was dependent upon high levels of carbohydrate food reserves as a source of energy. This rationale explains why bromegrass plants entering the winter period with low levels of stored food reserves may be especially susceptible to winter stresses that involve several periods of alternating freeze and thaw periods as occurred during 1982-83.

Conclusions

Seeding-Year Forage Yields and Quality

Seeding-year harvest near 20 August or earlier resulted in low forage yields, especially if planting date was near 1 June or later. That low yield was low in percent dry matter but high in percent crude protein. If a seeding-year harvest is to be taken before 20 August, bromegrass should be planted as early as possible to ensure an appreciable forage yield. For example, planting Polar bromegrass on 18 May resulted in two-year mean forage dry-matter yield on 19 August of 1.6 T/A, while planting 1 June with harvest on the same date resulted in only 1.1 T/A.

Seeding-year harvest after 20 September of bromegrass planted near 1 June resulted in over 1.5 tons of dry matter per acre, but of lowered quality as indicated by relatively high percent dry matter and low percent crude protein in herbage. Late planting (mid-June) resulted in much lower forage yields than earlier plantings, regardless of seeding-year harvest dates, though latest harvests resulted in highest yields.

Seeding-Year Harvest Dates and Subsequent Winter Survival

Smooth bromegrass, spring-planted without a companion crop, exhibited considerable sensitivity to time of seeding-year harvest. The cultivar Manchar, when harvested about 10 September, and Polar, harvested near 1 September, were predisposed to considerably greater winter injury and markedly more reduced first-cutting forage yields in the second year, than resulted from earlier or later harvests.

Accordingly, the period from about 20 August to 20 September should be avoided for seeding-year harvest of bromegrass for best subsequent stand vigor and winter survival.

A parallel to these results was found in another investigation at this station concerning the effects of three planting dates and several seeding-year harvest dates on winter survival and second-year spring forage yields of Siberian wildrye (*Elymus sibiricus* L.) (Klebesadel 1993b). Stands of that species were severely injured by seeding-year harvest near mid-September, but that effect was seen only in the latest (24 June) planting and not in grass planted earlier (6 June or 19 May).

Stored Food Reserves

Pre-winter levels of stored food reserves present in plants in mid-October were highest in plants that had been harvested earliest, and levels in plants decreased as plants had been harvested at later dates. Although the pre-winter levels of stored food reserves as influenced by seeding-year harvest dates (Fig. 7) did not parallel perfectly the forage yields obtained in the first-cutting forage harvest in the second year (Fig. 9), the similarities strongly suggest that (a) time of seeding-year harvest influenced levels of stored food reserves present at termination of the growing season, and (b) those levels of food reserves in turn influenced winter survival and subsequent stand vigor as measured by second-year forage yields. Other investigations at this location have found in several plant species that high levels of stored food reserves were associated with superior winter survival, and plants with lower levels exhibited poorer winter survival (Klebesadel 1985, 1991, 1993a, 1993c; Klebesadel and Helm 1986).

Results in the present experiments suggest that with harvest in early August, a sufficient portion of the growing season remained for the grass to draw upon previously stored reserves to put forth new leaf growth (Fig. 13). That regrowth then succeeded during a term of several weeks of photosynthetic activity in restoring adequate levels of food reserves prior to termination of the growing season.

Conversely, with a late seeding-year harvest on 20 September or later, lowering temperatures served to prevent active regrowth of plants (Figs. 4-B, 13), thus not depleting stored food reserves.

The most damaging harvest dates, 10 September for the Manchar plants and end of August for Polar plants, were early enough to cause plants to initiate some regrowth (Figs. 4-B, 13), which occurred at the expense of previously stored food reserves, but apparently were not early enough for that regrowth to restore high levels of food reserves as occurred after seeding-year harvests before mid-August (Fig. 7).

The higher levels of stored food reserves in bromegrass harvested before early August than in plants not harvested until late September or early October may be related to leaf age and the functional efficiency of leaves of different ages. Of interest in this regard is graphical data presented by Reynolds and Smith (1962) in Wisconsin showing higher levels of food reserves (measured as percent total available carbohydrates = TAC) at the end of the growing season in one-year-old plants of bromegrass that had been harvested two or three times during the year than where plants were not harvested. With bromegrass that was not harvested, percent TAC in storage tissues at final sampling on 11 November was only about 24%. However, with two and three harvests of bromegrass herbage during the growing season, percent TAC on 11 November was considerably higher at about 34% and 32%, respectively. With both harvest frequencies reported by Reynolds and Smith, the final harvest was on 29 August, leaving about seven weeks for regrowth and plant function with new leaves before occurrence of the average first killing frost date in southern Wisconsin.

Those results may be analogous to findings in the present study wherein superior winter survival and better subsequent spring vigor were noted with plants that had been harvested in early August of the seeding year than where plants were harvested late and closer to occurrence of killing frost. This suggests that an abundance of younger leaves during the late portion of the growing season were more responsive, efficient, and functional than older leaf tissue during the critical

Figure 13. A portion of Exp. VI showing Polar bromegrass plots planted 1 June 1983 and amounts of regrowth following harvests on various dates during that year. Photo taken 7 October 1983 near end of growing season. Tall, unharvested growth remains in place on plots to be harvested on final date (10 October), 3 days after photo. Apparent scenario: Plot A, harvested 19 August, had adequate time before winter to put forth a ground cover of leafy regrowth and restore sufficient food reserves before winter for good stand health; plot B, harvested 9 September, produced virtually no regrowth; plot C, harvested 30 August, put forth some regrowth that reduced previously stored reserves, but insufficient duration of growing season remained to restore deplenished energy levels and stand was therefore weakened prior to winter.

late-summer and autumn period when active photosynthetic activity is desirable for pre-winter storage of food reserves (Fulkerson 1970; Klebesadel 1985, 1991, 1993a, 1993c; Klebesadel and Helm 1986; Reynolds and Smith 1962; Smith and Graber 1948; Smith and Nelson 1985).

Management/Plant/Environment Interrelationships

Beyond concerns for the necessary presence of leaves for photosynthetic activity for pre-winter manufacture and storage of food reserves, leaves also play a vital role in other simultaneous activity. During the pre-winter period, plants are also induced by lowering temperatures and shortening daily photoperiods (and/ or lengthening nights or nyctoperiods) to undergo physiologic changes that render overwintering tissues tolerant to freezing (Hodgson 1964) resulting therefore in successful winter survival (Klebesadel 1971). During the time that leaves manufacture food reserves to provide the energy needed for pre-winter development of cold hardiness (Smith and Nelson 1985), a certain abundance of leaves logically must be present also to serve as receptors of the photoperiod/ nyctoperiod stimulus that (along with lowering temperatures) induces development of freeze tolerance.

Future research should be pursued concerning the influences of harvest dates on removal and regrowth of leaves, leaf age vs. efficiency, plant energy levels and the development of freeze tolerance, and the dynamics of the interaction of leaf abundance and the photoperiod/nyctoperiod stimulus. Future findings in this arena should be informative and helpful in formulating improved understanding of the complex management/plant/ environment interrelationships that produced the results reported here.

Weed Control

Most farm soils in Alaska contain great quantities of weed seeds that begin growth when brought near the surface by tillage and when temperature and moisture conditions favor germination.

An effective broadleaf herbicide was used in all of the experiments reported here. The only loss of an experiment to weed growth was the last (mid-June) planting of Polar bromegrass in Exp. VI; bromegrass seedlings were overwhelmed by a vigorous volunteer growth of annual bluegrass, a species not controlled by the broadleaf herbicide used.

For successful establishment of bromegrass without a companion crop, as done in these experiments, an effective, selective herbicide, approved for local use, probably will be necessary.

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